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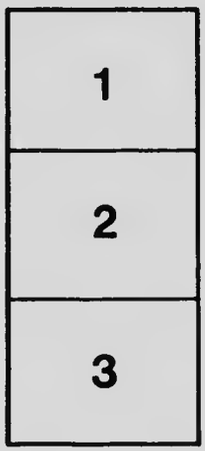

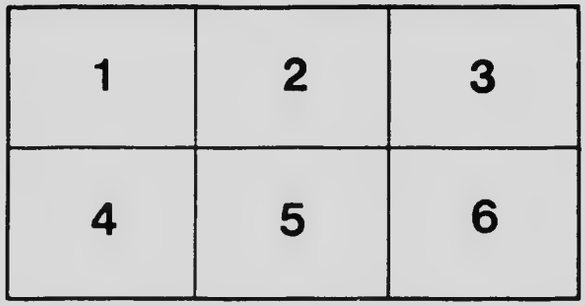

THE

LARGE LARCH SAW-FLY

(*Nematus erichsoni*).

a only

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THE LARGE LARCH SAW-FLY.

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An account of the Large Larch Saw-fly (*Nematus erichsoni*) has already been given in this *Journal*.* In it Packard's account of its life-history as well as the history of the pest in America and Europe, was summarised, but as the insect was practically a new pest, its life-history and bionomics had not been studied in this country. The present paper is intended to supplement MacDougall's account, and contains the results of a study of the life-history, parasites, and natural enemies of the saw-fly, together with recommendations as to remedial and preventive measures resulting from the investigation. The complete manner in which the previous history of the pest is given in Packard's careful descriptions† of its occurrence in the United States of America, and in MacDougall's *résumé*, makes it unnecessary to repeat this information here, and the subject is now taken up at the point at which these authors left off.

The egg, larva, female saw-flies and cocoons have been described, but the male, so far as I am aware, has not been

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* *MacDougall, R. S.* "The Large Larch Saw-fly (*Nematus erichsoni*)." *Journ. Board of Agriculture*, vol. xiii, pp. 385-394, 1 pl., October, 1906.

† *Packard, A. S.* Fifth Report of the United States Entomological Commission, "On Insects Injurious to Forest and Shade Trees" (*N. erichsonii*, pp. 879-890, pls. ix and xxvi.

mentioned. Packard does not appear to have seen one. This is no doubt on account of its rarity. *N. crichsoni* has been shown by the present investigation to produce almost solely by parthenogenesis, that is, the larvæ hatch out from eggs which have not been previously fertilised by males. This phenomenon occurs in other species of saw-flies (Tenthredinidæ), for example, in the common Gooseberry or Currant Saw-fly, *N. ribesii*. That this form of reproduction takes place was proved not only by segregating the females immediately on their emergence from the cocoons, but also by the fact that out of 300 cocoons which were specially observed only 2 males emerged to 298 females.

Description of Male.—The male is smaller than the female. Its length is 9 mm. and expanse of wings 15 mm. (the female is 11 mm. in length with a wing expanse of 20 to 21 mm.). The terminal portion of the abdomen is broadly rounded. The legs are paler in colour than those of the female, and only a small portion of the distal extremities of the tibiæ of the third pair of legs is dark coloured.

Life-history.—The female saw-flies began to emerge from the cocoons on 27th April (at an average temperature of 55° F.), but the largest number emerged from 29th May to 3rd June. At my request, Mr. Edwards, Forester on the Manchester Water-works estate at Thirlmere, kindly observed the appearance of the saw-flies in the plantations, and the first was recorded on 1st June, which agrees with the period of maximum emergencies in my experiments. I observed females still on the wing in the Thirlmere district towards the end of July. From this it might be inferred that there were two annual broods, such as occur in certain other species of saw-flies, for example, in the Pine Saw-fly *Lophyrus pini*, but I was not able to obtain two broods in my experimental studies, even from the earliest emerged batches. The emergence of the saw-flies from the cocoons of the previous year under natural conditions extends over a period of about eight weeks, and this fact explains the frequent occurrence of both full-grown and recently hatched larvæ on the same tree, which, together with the presence of the adult saw-flies over such an extended period, might be taken as indicating that the species was double-brooded, in the absence of evidence to the contrary.

The females begin to deposit their eggs almost immediately after emerging from the cocoons, especially if the weather is warm and sunny; as they reproduce parthenogenetically there is no necessity for them to await fertilisation by the male. The eggs are deposited on the stems of the fresh green terminal shoots in small slits made by the saw-like appendages of the ovipositor. The slits are made along the shoots with the result that the green terminal shoot is killed by the numerous wounds and curls round in a characteristic manner (Fig. 3). The presence of these brown and curled dead terminal shoots is often a means of detecting the presence of the larvæ when they do not occur in sufficient numbers to indicate their presence by much defoliation of the twigs. The eggs appear to be deposited chiefly on the lower branches of the trees, as I found that on the trees which were only moderately attacked the larvæ were most numerous on the shoots of the lower branches and these usually showed signs of defoliation before the branches nearer the top of the tree. The beginning of the attack on the lower branches is probably explained by the fact which has already been mentioned, namely, that the females begin to lay almost immediately after emergence; they would naturally on emerging from the cocoons lying beneath the turf, &c., fly on to the lower branches first.

As Packard's detailed description of the different stages of the life-history has been given in a summarised form by MacDougall, I shall not repeat those of my results which are merely confirmatory. In one respect, however, my experiments did not agree with those of Packard. He found that the larvæ moulted three times, that is, there were four larval stages. The larvæ which I reared and kept under observation, several hundreds in number, moulted five times, there being six larval stages. This difference in our results may be due to the fact that the observations were made in different countries, and in the case of saw-fly larvæ, as also in lepidopterous larvæ, one cannot be dogmatic with regard to the number of larval stages. The larvæ hatched out in eight to ten days after the eggs had been deposited. The larval life extended over a period of three to four weeks, each larval stage lasting from three to four days. A typical life-history (Exp. No. N. 2) was as follows:—

Eggs deposited	31st May to 2nd June.
Larvæ hatched	10th June.
1st moult	13th to 14th June.
2nd "	18th June.
3rd "	21st June.
4th "	24th June.
5th "	28th June.
Larvæ began to spin cocoons	2nd July.

These larvæ were still alive in their cocoons on the 7th October, which is against the occurrence of a second brood, as previously mentioned.

The following facts may be noted in addition to those detailed by Packard. The larvæ begin to use the posterior end of the body for clinging in the second larval stage. When a little more than half grown, that is, after the third moult, the larvæ begin to congregate in masses similar to those formed by the Pine Saw-fly, *L. pini*; this fact is important practically as will be shown in discussing the remedial measures. The mature larvæ congregate to a certain extent but not so densely as the younger ones.

Packard states that once shaken off the trees the larvæ cannot ascend the trunk, and he consequently recommends jarring the trees as a good remedy. I have very frequently observed the larvæ ascending the trunks of trees from which they have been either shaken off or washed off by rain; they travel slowly but ultimately regain the twigs.

General description of the Attack and its Effects.—The ages of the larches which are attacked by the saw-fly vary from 5 to about 100 years, that is, practically from the youngest to the oldest. Many of the young plantations consisting of larches of six to eight years of age were badly attacked, but the older plantations of trees from twenty to fifty years of age were affected most seriously, and the results of defoliation by the larvæ are more apparent on the older trees than on the trees in the young plantations.

The effect on the trees of the defoliation by the larvæ has been a matter of considerable discussion among owners and others, and there appears to be a tendency to minimise the evil which may result from such repeated annual defoliation. In the United States of America, Packard mentions that in certain regions from 10 to 30 per cent. of the trees were destroyed by the larvæ. There is now, however, evidence in the Lake District of the fatal effect of repeated defoliation. In the

Dodd plantation on the south-east side of Bassenthwaite Lake, which belongs to Miss Spedding, and which I visited in July, about 200 acres are attacked, and the trees were almost entirely defoliated at the time of my visit. The presence of the larvæ, I was informed by Miss Spedding's head woodman, has been visible for about six years, but he had never seen anything similar to it either in the Dodd or in the neighbouring plantations during the sixty years he had lived in the district. The result of this prolonged attack is that many hundreds of the trees have already been killed and many are dying; of the trees dead and dying 3,000 have been cut down and, I am informed, there are twice as many still to be felled.

It is not difficult for the biologist to understand how the death of these trees has been caused by the ravages of the larvæ. Like most rather closely planted fell-side larches they have merely a crown of green leaves from which to obtain their organic food; if this small supply is repeatedly cut off, although possibly for only half its annual life, the tree cannot procure even a minimum amount of food. The result, therefore, of the repeated diminution of the annual store of food over a series of years is, as one would expect, fatal. The vitality of the tree is also affected in another manner. As a result of the defoliation, which is often complete by the beginning of August, the trees respond by putting forth a second crop of green leaves, and the defoliated plantations have a green appearance when all the unattacked larches have lost their leaves. This will not only weaken the already diminished vitality by drawing on the small amount of the stored food of the tree, but further injury may result through the destruction by frost of the second crop of leaves.

Distribution of Nematus erichsonii in the Lake District.—A fairly complete inspection of the district was made in August, 1908, with a view to ascertaining the extent and intensity of the attack, but as it was not possible to visit the whole of Cumberland and Westmorland the absence of a plantation from this list does not necessarily indicate the absence of the saw-fly from that district. I believe, however, from visits that I have made to neighbouring localities, that the attack is at present confined to the Lake District. The insect was found in the following localities:—

Windermere District.—North. Between Rydal Water and Grasmere (p.),* W. side of Grasmere (d.p.), Elterwater (p.), Skelwith Bridge (p.), S.W. of Clappersgate (p.), near Lady Park (p.), about Barn Gates Inn (p.), Black Crag plantation (p.), near Borwick Lodge (p.). *East.* Garburn Pass (p.), Troutbeck (p.), Borrans (p.), N. of Staveley (p.), Long Sleddale (p.). *South.* Near Newby Bridge. *West.* Esthwaite Water, E. side (p.), Sawrey (p.), Claife Heights (p.), Grizedale (p.).

Coniston District.—East. Heald Brow plantation (p.), Coniston Moor plantation (p.). *North.* Waterhead (p.), High Cross plantation (p.), Hawkshead Hill (p.).

The Langdales.—Chapel Stile (p.), plantations on N. and W. sides of Lingmore Fell, N. of Great Langdale Beck and near Mill Beck (p.), Blea Tarn (p.), N. of Little Langdale Tarn (p.), plantations on High Park Fell and Park Fell (p.).

Eskdale and Wastwater.—Eskdale (p.), near Santon Bridge (p.), near Strands (p.), W. of Wastwater (p.), Wastdale and Mosedale (p.).

Ennerdale District.—W. end of Ennerdale (p.), about Lamplugh (p.).

Lowestwater.—Larches on S. side (d.p.).

Lorton Vale.—Plantations along and on W. side of the vale (p.), W. of Low Lorton (d.p.), Whinrigg plantation (d.p.).

Buttermere.—Plantation, S.W. (v.b.), N.E. plantation (b.), plantation near Gatesgarth (v.b.).

Borrowdale District.—Seathwaite (b.), Thornythwaite (v.b.), Rosthwaite (Johnny Wood, &c.) (d.p.), Watendlath (d.p.).

Derwent Water District.—Lodore (d.p.), Brandelhow Park and Lingholm (d.p.), Keswick (p.), Great Wood (d.p.), Rakefoot Pike (d.p.).

Bassenthwaite Lake.—N. of lake (p.). *West* and *South West.* Mines (?) plantation (b), Combe plantation (v.b.), Hospital plantation (v.b.), Braithwaite (d.p.). *South East.* Dodd plantation (v.b.), Millbeck (b), Latrig (d.p.).

Thirlmere District.—North. Shoulthwaite plantation (v.b.), St. John's Vale (p.). *East* and *West.* Plantations (b.), chiefly (v.b.).

Ullswater District.—West. Matterdale (p.) and (d.p.), W. side of lake (p.), Glenridding (p.). *South.* Hartsop (p.).

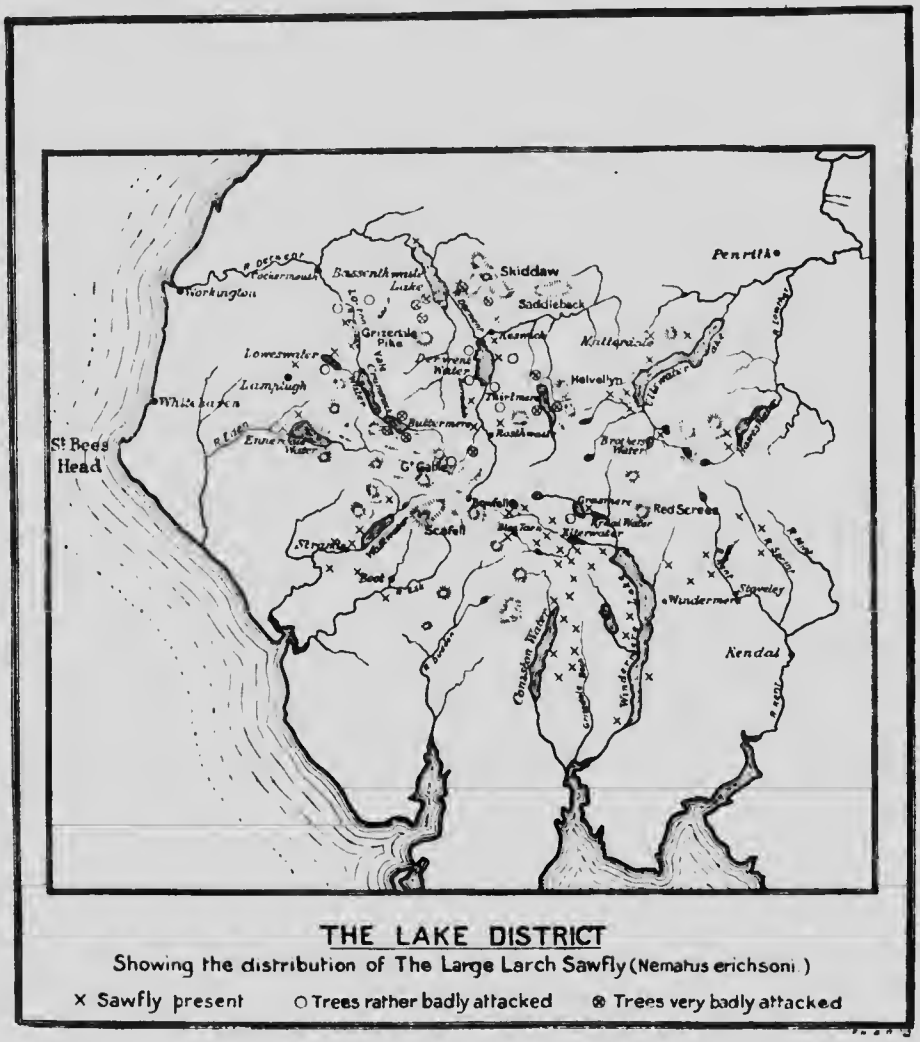
Hawes Water.—Larches at S. end (p.).

The distribution of the saw-fly and the intensity of the attack will be readily understood from the accompanying map.

Means of Detection.—If the larvæ are present in any number there will be sufficient evidence of their presence in the number of defoliated twigs, which give a brownish winter appearance to the branches when seen from a distance. If the larvæ are still young their presence can be detected by the brown and slightly curled appearance of the green leaves near the ends of the twigs, which is due to the young larvæ partially devouring them, usually along one side. In the case of larvæ occurring at the top of tall trees, if their presence cannot be detected by the defoliation of the twigs of the lower branches, it is generally indicated by the small green cylindrical fæcal pellets which may be found round the base of the tree; these are figured in

* NOTE.—(p.) indicates that the insect was present, though in such small numbers that its presence would not be noticed by an untrained observer. (d.p.) in these plantations or groups of trees the insect was distinctly present. (b.) indicates that the trees were badly attacked, and (v.b.) indicates that the attack was very bad, the trees being completely defoliated.

MacDougall's paper. A further means of detection has already been mentioned, namely, the dying off and curling round of the short terminal shoots, which is caused by the injury inflicted by the females in depositing their eggs.



THE LAKE DISTRICT

Showing the distribution of The Large Larch Sawfly (Nematus erichsoni)

× Sawfly present ○ Trees rather badly attacked ⊗ Trees very badly attacked

Natural Enemies.—The most important factors in the natural control of the saw-fly which have so far been discovered are birds, and, as will appear strange, the small Field Vole—*Microtus* (*Arvicola*) *agrestis*.

When the larvæ were in the earlier stages it was found that the three species of Tits—the Great Tit, Cole Tit, and Blue Tit—fed upon them to a considerable extent. They were also assisted by Chaffinches, which were found feeding on the full-grown larvæ. In addition to these birds, which perform no little service, great destruction of the larvæ was effected by the Rooks, Jackdaws, and Starlings which were to be seen in large flocks in and about the more seriously attacked plantations. They not only fed upon the larvæ on the trees but also followed them on to the ground when about to spin their cocoons beneath the turf. When the larvæ had reached this stage one frequently found that the Rooks had riddled the turf round the bases of the trees with holes in search of the larvæ.

Birds do not normally care for such resinous larvæ as those of *N. crichsoni*, but the present case is an example of a phenomenon which sometimes occurs when an insect assumes unnatural proportions and becomes a pest, and where the presence of a large amount of food temporarily alters the feeding habits of many of the birds of that locality.

During the winter months when the larvæ are enclosed in their tough cocoons they are safe from the attacks of their avian enemies, but it was discovered as a result of observation and experiment that the small Field Vole, *Microtus agrestis*, Flemming (Fig. 1), proves itself of very great service in extracting the larvæ from the cocoons and eating them. This small rodent burrows beneath the turf and litter round the bases of the trees in search of the cocoons; having found a cocoon it nips a small piece off one end and draws out the enclosed larva,* which it then devours. The presence and activity of the voles is attested by the numbers of empty cocoons gathered in small groups in the runs that they have made and the teeth-marks of the voles can be readily distinguished on the empty cocoons (see Fig. 2). During last winter (1907-8) these animals destroyed large numbers of the larvæ in all the plantations on the Thirlmere watershed which were badly attacked. From observations made in different plantations I calculated that they had destroyed about 25 per cent. of the pupating larvæ. Further, dissections of their stomachs and microscopic examina-

* The saw-fly larva remains in the larval stage in the cocoon until about May of the following year, when it changes into the pupa.

Fig. 1. The Small Field Vole — *Microtus agrestis.*

Fig. 2. Cocoons of Large Larch Sawfly. — *Nematus erichsonii.*

Fig. 3. Dead Terminal Shoots of Larch.

Fig. 4. Ichneumon — *Mesoleius antennatus* Grav., A Parasite of the Large Larch Sawfly.

tion of the contents showed that they were largely subsisting on the saw-fly larvæ. The normal phytophagous habits of this vole are well known, and this raises a fine question as to the real economic value of the animal in the case of the present attack; this will be discussed later.

Insect Parasites.—It sometimes happens that an insect pest which has assumed large proportions in a certain region disappears almost as quickly as it appeared. This is often due to the fact that the insect parasites of the injurious insect increase to so great an extent that almost every individual becomes a host and is consequently destroyed. As in the case of lepidopterous larvæ the chief parasites of the saw-fly larvæ are the larval stages of the Ichneumons and certain other minute Hymenoptera. The larvæ of certain Diptera, such as the Tachinidæ, are also parasitic on the saw-fly larvæ. One of the objects of the present investigation was to discover what species of parasitic insects affected *Nematus erichsonii*. So far two parasites have been found, one of which is an Ichneumon, which Mr. Claude Morley very kindly identified for me as *Mesoleius aulicus*, Grav., and the other was a dipterous larva.

Mesoleius aulicus, *Grav.* (Fig. 4).—It was found that the proportions of cocoons which contained this parasite varied in batches of cocoons from different plantations. From one batch of 136 cocoons 13 Ichneumons emerged that is, 9·4 per cent. of the larvæ had been parasitised; a batch of 176 cocoons from another plantation yielded only 6 Ichneumons, that is, only 3·4 per cent. of the saw-fly larvæ contained the parasites. It is of importance to study the numerical proportions of the parasites in the different localities, as it may eventually be found that in certain localities the percentage of cocoons containing parasites is so great that some practical benefit may accrue from the distribution of these highly parasitised cocoons in localities where the percentage of parasites is much lower. This species of Ichneumon appeared to be fairly numerous this year, as I saw several on the wing during my July visit to the affected plantations.

*Description of M. aulicus.** —This insect belongs to the

* For a full description, see *E. H. Ashton.* "Forsök till uppställning och beskrifning af de i Sverige funna Tryphonider." *Kongl. Vetens.-akad. Handl.*, 1855, p. 134.

group of Ichneumons—the Tryphoninæ. The head is black except in the male, in which the facial region is yellow. The antennæ, which are long and 34-jointed, are black, as also is the rest of the body of the insect. The first and middle pairs of legs are uniformly coloured yellowish brown. The basal joints of the third pair of legs are resinous brown, the tip of the third (femoral) joint being black, the rest of the leg from about the middle of the fourth (tibial) joint is also black. Its length is 9·5 mm. (about $\frac{3}{8}$ in.) and the breadth across the wings is 17 mm. (almost $\frac{11}{16}$ in.).

Dipterous Larva.—Two specimens of the larva of a species of Dipteron were obtained from the larvæ of *N. erichsoni*. As no mature insects of this parasite were obtained it is extremely difficult on account of our scanty knowledge of the larvæ of Diptera to identify even the genus. I believe, however, that they are Tachinidæ belonging to the sub-family Sarcophaginæ. They appeared to be mature and measured 10 mm. in length.

Remedial and Preventive Methods.—In combating a pest of this nature, where large areas of mature trees, growing chiefly on mountain and fell sides that are difficult of access, are attacked, we are faced with enormous difficulties. In the first place many of the methods usually suggested against such insects, although they may be suitable for isolated trees of an ornamental character or small groups of trees, if they are not quite impracticable on a large scale, entail a greater expense in their execution than the value of the timber will allow.

It was found that the method of burning the litter and turf which surrounds the bases of the trees and contains the cocoons though very efficacious was much too costly, even where the plantation was fairly accessible.

The plan of jarring the trees suggested by Packard is not to be recommended as I have already mentioned, unless the larvæ be caught in outstretched sheets beneath the trees and subsequently burnt.

Where plantations of young trees are attacked it is easier to take active measures. Spraying with arsenite of copper is effectual and has the advantage of being cheap. A pound of arsenite of copper is dissolved in 150 gallons of water; from 4 to 6 quarts of flour are mixed with the solution to make it more adhesive to the foliage, the flour being put into the

solution through a fine wire gauze to divide it finely. But a still more effectual method of destroying the younger larvæ is to crush them with a gloved hand. For this method to be carried out rapidly and to secure the best results, the larvæ must be carefully watched until they reach the stage where they congregate in masses, that is, about the third and fourth larval stages; in this stage of the life-history I have counted as many as sixty larvæ in a single mass, all of which could be easily destroyed by a single closing of the hand. If they are dealt with in this manner a number of men can quickly clear a plantation of young trees from five to eight years of age. Spraying might be restricted to the slightly older trees whose upper branches are out of reach. Hand-picking also proved very effectual in the case of young trees.

In the older plantations it is necessary to rely on natural means of control, such as have been mentioned already. Some natural means of control, however, can be assisted and augmented, and such is the case with regard to the birds which have been mentioned as feeding on the larvæ; chief of these are rooks, starlings, jackdaws, and tits. In the districts where the trees are badly attacked these birds should not be destroyed on any account. The starlings and tits should be encouraged and protected by feeding them during the winter and thus preventing the customary great mortality which results from hard weather, and also by the provision of nest-boxes in the plantations. Larch plantations are singularly devoid of suitable nesting places for these birds and they should therefore be supplied. In England these insectivorous birds are not sufficiently encouraged in places where nesting sites are absent by the provision of nesting boxes, the value of which form of forest protection has been recognised for a number of years in Continental forests. The best type of nest-box is that designed by Baron von Berlepsch.*

As the Field Vole, *M. agrestis*, has been shown to be an important means of control by destroying the larvæ in the cocoons, it would be in the interests of the forester not to destroy the vole until the saw-fly attack shall have subsided. If it is found that they are increasing to any alarming extent and attacking

* "How to Attract and Protect Wild Birds," by M. Hiesemann. Translated by Emma S. Buchheim. London: Witherby, 1908.

young trees, it will be necessary to take active measures against them, but unless this occurs, in view of the great assistance derived from their presence in combating the saw-fly, it would be advisable neither to destroy nor encourage them.

In districts where the attack of the saw-fly is pronounced it would be well to postpone the planting of young larch trees, unless some remedial measures such as have been suggested can be carried out. If the land cannot be spared another species of conifer might be planted, as *N. erichsoni* strictly confines its attention to the larch.

If the natural means of control, such as birds, are encouraged, and it is upon these and the parasites that the extermination of the pest chiefly depends, the attack will last for a much shorter length of time, and there will ultimately be a less pecuniary loss than if a policy of *laissez faire* be adopted.

[illegible]

Fig. 1. The Small Field Vole, *[illegible]*, which feeds largely on the larvæ of the saw-fly during the winter months. (Three-quarters natural size.)

" 2. Cocoons of *[illegible]*, from which the larvæ have been extracted by the Field Vole. The characteristic hole is usually visible on many of the cocoons shown. (Natural size.)

" 3. Dead terminal shoots of Larch, showing characteristic curled appearance, caused by the wounds made in the spring by the female saw-flies in depositing their eggs.

" 4.—*[illegible]*, Cam. An Ichneumon parasite of the larch saw-fly. Three times natural size, which is shown by the cross lines.

I am indebted to Dr. O. V. Darbishire for photographing Figs. 1 and 4.

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